SCHEDULING THE INSTALLATION OF THE LARGE HADRON COLLIDER

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Abstract

The size and complexity of the LHC project at CERN calls for a strong co-ordination of all installation activities. The detailed installation planning has to take into account many constraints such as the component production rates, the installation contracts or the transport and handling requirements in a narrow tunnel with limited access points. The planning also needs to be flexible enough to cope with aleas that are unavoidable in such a large project that spans over many years. This paper describes the methodology followed by the team responsible for the planning and logistics in order to stay reactive to the actual progress of the installation and to keep optimising the usage of resources.

INTRODUCTION

Since the LHC project has been approved by the CERN council at the end of 1994, the most important goal is to build a working accelerator on time. The organization of the LHC installation has been described, at the level of general principles, in several documents issued at the time the project was launched [1, 2], leading to the **Planning Methodology** described below. The **Installation Sequence**, which is the basis of the different scenarios that were studied, has been chosen in order to minimize interferences and consequently the amount of time lost. Still, unforeseen situation in the field or procurement issues, identified through the **Planning Follow-up** process, may lead to some **Adaptation of the Planning** that needs to be accepted by all parties involved.

PLANNING METHODOLOGY

A complex project spanning over many years, even decades, is difficult to manage with a single network planning. Opting for a multi-level planning allows concentrating on the different phase of the project and is more efficient in term of project staff involvement. LHC planning presents 3 levels where, below the Master Schedule, the General Co-ordination Schedule and the Detailed Installation Schedule are specific to the installation activities.

- The Master Schedule reviews the strategic goals and major milestones of the project. It gives a schematic of the different phases of the installation, indicates the main dates and shows the sequence of work in the different sectors of the LHC. It is prepared by the planning coordinators, verified and approved by the project management. It is used for communicating progress outside the project team; the Master schedule may be actualised at management request.

- The General Co-ordination Schedule is issued by the planning coordinators with the aim to implement and control the flow of installation that is most effective in term of resources and time. It has to respect the main milestones of the Master Schedule, such as injection tests in TI8, tests of sector 7-8 with beam, closing of the machine, end of the LHC installation. It is based on the Work Breakdown Structure (WBS) and activity list. It is verified and approved by technical groups, and endorsed by the project management. This schedule is a "chemin de fer" type. This representation allows visualizing all the activities in all the areas and during the whole period of the project in one sheet. This document represents the baseline of the project, which is essential to the project follow-up.

- The Detailed Installation Planning derives from the details of the installation scenario and the knowledge of each individual installation work unit (activities, boundary conditions, resources, etc.). The aim of this schedule is to insure that the resources required to achieve every task are available, and that the work to do is feasible within the time slot allocated. It is maintained with the MS-Project package, which updates automatically all the chronological relations between the different activities whenever a schedule change or a new task is introduced. It also provides a resource levelling function that is very useful to assess the feasibility of a new scenario.

INSTALLATION SEQUENCE

The time allocated to the LHC underground installation is about 5 years, excluding civil engineering. The installation of the machine elements in a sector is expected to last three years.

The installation of LHC is subdivided in twelve steps [3] that can be grouped in 4 main phases occurring at different times in each sector. Presently, a detailed scenario is available for the installation of the arcs and injection lines [4]. The installation sequences for the other sections (RF, extraction, cleaning, etc.) of the machine still need to be consolidated.

The planning process reviews and allocates time slots to every installation steps which are listed below for what concerns the arcs:

Phase 1: General services

- Step 1: Floor Marking and Floor Preparation
- Step 2: Electrical General Services Installation
- Step 3: Piping Work
- Step 4: Cabling Campaigns #1

Phase 2: Cryogenic line

- Step 5: Installation of the QRL
- Step 6: Cabling Campaign #2
- Step 7: Commissioning and Reception tests of the QRL

Phase 3: Machine

- Step 8: Installation of the Support Jacks
- Step 9: Transport of Cryomagnets onto Jacks
- Step 10: Interconnection of the Cryomagnets
- Step 11: Installation and connection of Local Electronics below Cryomagnets

Phase 4: Hardware commissioning

- Step 12: Cool down and Powering tests of the Electrical Circuits

Several protagonists usually intervene in the same locations during overlapping time intervals and it is necessary to make sure of the compatibility of all the works. The installation of the LHC has thus been broken down in Work Packages which cover a given phase of the LHC installation, within a set of underground areas that are logically linked (Sectors, injection line, etc…). The Work Package documents, which contribute to the quality assurance process of the LHC project [6], are thus refer to the planning (Co-ordination Schedule and Detailed Installation Planning discussed in the previous paragraph) and complete the information required for the chronology of the activities.

PLANNING FOLLOW-UP

The aim of the project follow-up is to depict the actual status and to compare it to the baseline planning. The first level of information is obtained through weekly meetings organised in the field with the aim to follow the advancement progress of every installation work and to identify potential problems. Minutes of these weekly meetings are available and archived in the LHC Engineering Database Management System (EDMS).

The Installation Follow-up Meeting, which takes place every 4 weeks, is the occasion of a global review of the situation: this is a forum to share experience and to check the homogeneity of the installation procedures on the different work sites.

Finally, regular progress report would cover the following points:

- The work which has been achieved in the last month both qualitatively and quantitatively;
- The problems which has been encountered during the last month, the corrective actions taken and the consequences foreseen for remaining works;
- The actual status of the project compared with the baseline, and with the last month status.

These progress reports are prepared by the planning coordinators. They are presented every month in the Technical Coordination Committee and published once a month on the WEB home page of the LHC project.

ADAPTATION OF THE PLANNING

The installation activities have to adapt through continuous feedback from the production sites and from the field. To this end, the detailed installation planning is actually reviewed, every 4 weeks, at the Short Term Planning Meetings whose aim is to confirm the activities to be carried over the 3 coming months. Early warnings of potential delays come up in this forum: interfaces between groups have not been identified or the task sequencing is incorrect, components or team are not available, preparation work or integration is not ready, time required to achieve a given task has been miss-evaluated or unexpected technical difficulties encountered. It is mandatory to limit the impact of such hazards, and a rescheduling of activities or a redeployment of staff to optimise the usages of resource might be considered. In the decision making process, solutions without consequences on other work units (co-activity if possible, night shifts…) are initially studied; then, at a second stage, those without consequences on work units under sub-contractors or vendors responsibility are preferred.

Minor changes

Rescheduling can be accepted rapidly if the impact is limited to the domain of activity of the project engineers present or represented at the Short Term Planning Meeting and if the dates of the General Co-ordination Schedule are respected. A revision of the Detailed Installation Planning is thus issued taking into account the actual component production and installation contracts as well as the actual progress of the installation.

Such direct rescheduling can be a hazardous exercise. Attention shall be kept in particular to the logistics of the supply of the different work sites since activity in a shaft (cabling, piping or installation of cryogenics lines) forbids lowering material through this shaft for the entire duration of the work. All safety aspects are also taken into account: security rules have to be strictly enforced and the new procedures must be studied and documented in all details. This is anyway a mandatory step to assess the feasibility of a new scenario.

Major changes

Still, if it appears that the change cannot be considered locally and that it has implication on the installation of other equipment occurring at different times and locations, the rescheduling must be known and accepted by all parties involved through a Schedule Change Request.

The Schedule Change Request describes the reason of the rescheduling, the solutions retained, the detail installation planning of the phase, as well as the impact on cost, schedule and performance.

Rescheduling of the installation, in particular if it concerns a complete phase has major consequences and involves many parties [6]. To obtain authorization for a schedule change, a Schedule Change Request is circulated

to all the Group Leaders involved in the LHC Project for them to evaluate eventual implications on the installation of their equipments and on their contracts.

When approved, the Project Leader declares the document as a Schedule Change Order and all the Project Engineers are informed.

CONCLUSION

The General Co-ordination Schedule represents the project baseline, which is used to monitor the advancement of the installation. This is the subject of progress reports presented every month at the Technical Coordination Committee and published once a month on the WEB home page of the LHC project.

However, scheduling the installation of the LHC is definitely a dynamic process: the Detailed Installation Planning is reviewed regularly to take account of delays and incidents that one cannot avoid in a one-of-a-kind project of the complexity of the LHC. The coordination group has adopted a pragmatic approach to implement schedule modifications through close interactions with all those who participate to the project, on the production site and in the field. When a change of the planning involves many parties, it has to be formally accepted through a Schedule Change Request that is circulated to all the Group Leaders involved in the LHC project.

Finally, one must be aware that prompt reactivity is a potential source of accident. The installation of the LHC requires carrying heavy equipment and a huge variety of material in very confined underground areas. Many teams share the same access path and work sites, sometime working on different levels. All safety rules must be strictly enforced and there is no emergency that can justify any derogation.

REFERENCES

[1] G. Bachy, A-P. Hameri, “What to be Implemented at the Early Stage of a Large-Scale Project”, CERN LHC Note no. 315, Geneva, March 1995

[2] G. Bachy, P. Bonnal, M. Tarrant, “A Planning & Scheduling System for the LHC Project”, CERN LHC Note no. 355, Geneva, September 1995

[3] R. Saban, “L’Installation du LHC – La Coordination sur le Terrain”, CERN LHC Project Document no. LHC-PM-IP-003, July 2003

[4] P. Bonnal, P. Proudlock, S. Weisz, “General Co-ordination Schedule”, CERN LHC Project Document no. LHC-PM-MS-0005, March 2003

[5] P. Bonnal, M. Vitasse, “Organization of the Installation Work of LHC and its Experiments”, CERN LHC Project Document no. LHC-PM-IP-0001, August 2002

[6] K. Foraz, S. Weisz, “Installation Schedule of Machine Elements in the Continuous Cryostat of Sector 7-8”, CERN LHC Project Document no. LHC-PM-MS-0013, March 2004